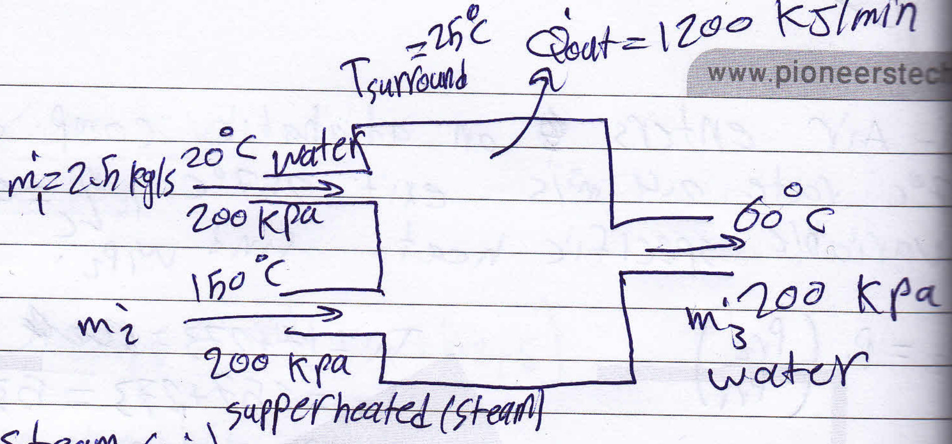
مهم جدا Ex:-



a) find $\dot{m}$ steam ($\dot{m}_2$)
b) Rate of entropy generated $\dot{S}_{gen}$

$\dot{m}_1 h_1 + \dot{m}_2 h_2 = \dot{m}_3 h_3 + \dot{Q}_{out}$

$\dot{m}_1 + \dot{m}_2 = \dot{m}_3$

$2.5 h_1 + \dot{m}_2 h_2 = 2.5 h_3 + \dot{m}_2 h_3 + \frac{1200}{60}$

$h_1 = h_f = 83.91$ KJ/kg
$h_2 = 2769.1$ KJ/kg
$h_3 = h_{f_3} = 251.18$ KJ/kg

$\dot{m}_2 = 0.166$ kg/s

$S_1 = S_f = 0.296$ KJ/kg·K
$S_2 = 7.281$ KJ/kg·K
$S_3 = S_f = 0.8313$

$S_{surr} = \frac{\dot{Q}}{T} = \frac{20}{298} =$

$\dot{S}_g = (\dot{S}_{out} - \dot{S}_{in})$
$= \left(\dot{m}_3 S_3 + \frac{\dot{Q}_{out}}{T_{surr}} - (\dot{m}_1 S_1 + \dot{m}_2 S_2)\right)$

$\dot{S}_g = 0.333$ KW/K.S

$$\boxed{S_{work} = 0}$$

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Ex:- Air enters an adiabatic comp. at 100 kpa and 17°c rate 2.4 m³/s exit 257°c , $\eta_c = 0.84$, variable specific heat. find w, P_2.

$$P_2 = P_1 \left(\frac{P_{r2}}{P_{r1}}\right)$$

$T_1 = 17 + 273 = 290\ K$

$T_2 = 257 + 273 = 530°K$

$T_1 = P_{r1} = 1.2311$

$T_2 = h_{2a} = 533.98\ KJ/kg$

$$\eta_c = \frac{h_{2,s} - h_1}{h_{2,a} - h_1} \Rightarrow h_{2,s} = 496\ kJ/kg$$

$P_{r2} = 7.951$

$$P_2 = P_1 \left(\frac{P_{r2}}{P_{r1}}\right) = 646\ kpa.$$

$$W_{in} + \cancel{Q_{in}} + \dot{m} h_1 = \cancel{W_{out}} + \cancel{Q_{out}} + \dot{m} h_2$$

$W_{in} = \dot{m}(h_{2a} - h_1)$

$=$

$$\dot{m} = \frac{P_1 \dot{V}}{RT_1} = \frac{100(2.4)}{0.287(290)} = 0.2884\ kg/s$$

$$S_{in} - S_{out} + S_{gen} = 0$$

↳ steady state devices.

$$\Delta S_{surrounding} = \frac{Q}{T_{surrounding}}$$

$$\eta_T = \frac{W_a}{W_s} = \frac{6000\ \text{KW}}{W_s}$$

$$\dot m(ke_1 + h_1) = W_{out,s} + \dot m(ke_2 + h_{2,s})$$

$$W_{out,s} = \dot m\left[(ke_1 - ke_2) + (h_1 - h_{2s})\right]$$

$$x_2 = \frac{s - s_f}{s_{fg}} = \frac{7.091 - 1.0912}{6.9019} = 0.9228$$

$$h_{2s} = h_f + x\, h_{fg}$$

$$= 340.54 + (0.9228)(2304.7) = 2467.3\ (\text{KJ/Kg})$$

$$W_{out,s} = 8174\ \text{KW}$$

$$\eta_T = \frac{6000}{8174} = 0.734$$

$P_2 = 2\,\text{MPa}$
$T_2 = 550°\text{c}$

$K =$

$P_1 = 200\,\text{MPa}$
$T_1 = 27°\text{c}$

assume constant specific heat.

find $\eta_{c,isent}$??

$$\eta_c = \frac{h_{2s} - h_1}{h_{2a} - h_1} = \frac{T_{2s} - T_1}{T_{2a} - T_1}$$

$$\frac{T_{2,s}}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{K-1}{K}}$$

Note:

* if ideal Gas :- $\eta_T = \dfrac{c_p(T_{2,a} - T_1)}{c_p(T_{2,s} - T_1)}$

Do the same for $\underline{\underline{\text{pump}}}$ or $\underline{\underline{\text{com}}}$ $\therefore$ $\boxed{\eta_T = \dfrac{T_{2a} - T_1}{T_{2s} - T_1}}$

مهم جداً | حل جامعة

Example ③ :- steam enters an adiabatic turbine at turbine at 7 MPa, 600°c, 80 m/s, and leaves at 50 kpa, 150°c and 140 (m/s) If the power output 6 MW.

a) mass flow Rate ?

b) Isentropic efficiency?

$$\cancel{Q_{in}}^{0} + \cancel{W_{in}}^{0} + \dot m(ke_1 + \cancel{pe_1}^{0} + h_1) = W_{out} + \cancel{Q_{out}}^{0} + \dot m(ke_2 + \cancel{pe_2}^{0} + \overset{\text{actual}}{h_2})$$

when all are actual we should use actual h
when isentropic we should use $h_{(s)}$

$$\dot m(ke_1 + h_1) = W_{out} + \dot m(ke_2 + h_2)$$

$$\dot m(ke_1 - ke_2 + (h_1 - h_{2,a})) = W_{out}$$

$$\dot m = \frac{W_{out}}{(ke_1 - ke_2) + (h_1 - h_{2,a})} = \frac{6000\,kW}{\left(\frac{(80)^2}{2000} - \frac{(140)^2}{2000}\right) +}$$

$T_1 = 600°c$ } super heated
$P_1 = 7\,MPa$ } $h_1 = 3650.6$ KJ/kg
$s_1 = 7.0910$ KJ/kg.K

$P_2 = 50$ kpa } $\rightarrow h_{2a} = 2780.2$ (KJ/kg)
$T_2 = 150°c$ }

$\dot m = 6.95$ kg/s

$\boxed{W_{pump} = P \Delta V}$ Just for pump

* Isentropic effiency :-

- always if we have $\underline{\underline{P}}$, and $\underline{\underline{T}}$ we will get the actual property

imp :- $\boxed{P_{2,s} = P_{2,a}}$ but $\boxed{T_{2,s} \neq T_{2,a}}$

always we ~~pre~~ try ~~to~~ to get $\underline{\underline{P}}$ not $\underline{\underline{T}}$ To solve the problem.

- $\eta_{Turp}\Big|_{isentropic} = \dfrac{h_1 - h_{2a}}{h_1 - h_{2s}}$

- $\eta_{\substack{comp \\ Pump}} = \dfrac{h_{2s} - h_1}{h_{2a} - h_1}$

if there is NO KE , PE

- if there is KE , PE :- $\eta_{Turp} = \dfrac{W_a}{W_s}$

- $\eta_{cp} = \dfrac{W_s}{W_a}$

* The Isentropic For Ideal Gas and The Isentropic effiency

$\boxed{K = \frac{C_p}{C_v} \quad \overset{air}{(1.3 \to 1.4)}}$

Isentropic Ideal Gas :-

Constant specific heat :-

① $\left(\frac{T_2}{T_1}\right)_s = \left(\frac{V_1}{V_2}\right)^{K-1}$

$TV^{K-1} = \text{constant}$

② $\left(\frac{T_2}{T_1}\right) = \left(\frac{P_2}{P_1}\right)^{\frac{K-1}{K}}$

$TP^{1-K/K} = \text{constant}$

③ $\left(\frac{P_2}{P_1}\right) = \left(\frac{V_1}{V_2}\right)^{K}$

Variable specific heat

① $\frac{V_2}{V_1} = \frac{V_{r_2}}{V_{r_1}}$

② $\frac{P_2}{P_1} = \frac{P_{r_2}}{P_{r_1}}$

$\boxed{\text{Table A-17}}$

$P_r \to$ relative pressur

$V_r \to$ relative volume

Don't Forget $\boxed{PV = mRT}$

* Now :-

a) $\Delta s = S_2 - S_1 = C_{p_{avg}} \ln\left|\frac{T_2}{T_1}\right| - \cancel{R \ln\left|\frac{P_2}{P_1}\right|}^{0}$

$\therefore$ ~~$\Delta S = 0.3$~~ $\Delta S = m \Delta s$

$\therefore \Delta S = (0.387)\ KJ/K$

b) $\Delta S = m(S_2 - S_1)$

$(S_2^\circ - S_1^\circ) - \cancel{R \ln\left|\frac{P_2}{P_1}\right|}^{0}$

$\boxed{A\text{-}17}$

$\therefore S_1^\circ = 1.66802 \quad KJ/Kg.K \quad at \quad T_1 = 290\ K$

$S_2^\circ = 2.5628 \quad KJ/Kg.K \quad at \quad T_2 = 698\ K$

The entropy change For Ideal Gas.

Constant :- approximate

① $S_2 - S_1 = C_{v_{avg}} \ln\left|\frac{T_2}{T_1}\right| + R \ln\left|\frac{V_2}{V_1}\right|$

② $S_2 - S_1 = C_{p_{avg}} \ln\left|\frac{T_2}{T_1}\right| - R \ln\left|\frac{P_2}{P_1}\right|$

* Note that : $\boxed{R = C_p - C_v}$

Variable (exac

$S_2 - S_1 = S_2^\circ - S_1^\circ - R \ln\left|\frac{P_2}{P_1}\right|$

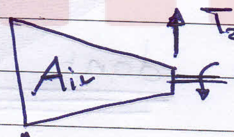
* Note that :- S_2°, S_1° From A-17 For Air only

* Example :- ① Find ΔS (entropy change) using :-

a) actul :-

b) approximate :-

$P_2 = 600$ KPa
$T_2 = 330$ K



$P_1 = 100$ KPa
$T_1 = 290$ K

* sol :-

b) $S_2 - S_1 = C_{p_{avg}} \ln\left|\frac{T_2}{T_1}\right| - R \ln\left|\frac{P_2}{P_1}\right|$

$\therefore T_{avg} = \frac{T_1 + T_2}{2} = \underline{\underline{310 \text{ K}}}$

* Now From A-2b we Find $\underline{\underline{C_{p_{avg}}}}$ at 310 K, $\underline{\underline{C_{v_{avg}}}}$

$\therefore R = C_{p_{avg}} - C_{v_{avg}} = 0.287$

a) $S_2 - S_1 = S_2^\circ - S_1^\circ - R \ln \left| \frac{P_2}{P_1} \right|$

* since : S_1° , S_2° From A-17

$T_1 = 290$ K → $S_1^\circ = 1.66802$ KJ/Kg.K

$T_2 = 330$ K → $S_2^\circ = 1.79783$ KJ/Kg.K

* Example ② :- An insulated piston-cylender device initialy contains 300 L of air at 120 KPa, 17 °C. Air is Now heated for 15 min by a 200 W resistance heater placed inside the cylender. The pressure is mainted constant, Determin The entropy change assuming :-

a) constant specific heats.

b) variable " " .

State one → State two

Constant Pressure

$P_1 = 120$ KPa

$T_1 = 17$ °C

$V_1 = 0.3$ m³

$P_1 V_1 = m R T_1$

$m = 0.4325$ Kg

$\therefore \cancel{Q} + W_{in} = m \Delta h$

$\therefore W_{in} = m(Cp_{avg}(T_2 - T_1))$

but: $W_{in} = 200 * 15 * 60$

$\boxed{W_{in} = 180 \text{ KJ}}$

$P_2 = 120$ Kpa

$T_2 = ??$

Tabl A-26 at T_1

Now :- $180 = (0.4325)(Cp)(T_2 - 290 \text{ K})$

$\therefore \boxed{T_2 = 698 \text{ K}}$

Type of process entropy

- entropy Change
  - Steam
    - Isothermal
    - not Iso thermal
  - Ideal Gas
    - $\boxed{\text{Constant spacific heat}}$
    - $\boxed{\text{Variable specific heat}}$ table A-17
- Isentropic (Internaly Reversible + Isothermal)
  - Steam
  - Ideal Gas
    - $\boxed{\text{Constant specific heat's}}$
    - table A-17 $\boxed{\text{Variable specific heat}}$

* **Ideal Gas :-**

- don't forget :-

① $PV = mRT \rightarrow K$

P → KPa, V → m^3, m → Kg, R → KJ/kg.K

$\boxed{A-1}$

② $P = \rho RT$

③ $P = \frac{RT}{v}$, $v \rightarrow m^3/kg$

④ If the Process is Isentropic Process :-

Use T_{actul} , $P_{actul, Isentropic}$

dont use $\rightarrow T_{Isentropic}$

Since :- $\boxed{P_{actul} = P_s}$

$\boxed{T_{actul} \neq T_s}$